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June Thunderstorms

By C. K. M. DOUGLAS, B.A.

There was a spell of thundery weather from June 12th to 19th, culminating in widespread and severe storms on the 18th. Pressure during the period was high from Scandinavia to the Azores, low round south Greenland, and relatively low on the continent, where thunderstorms were numerous. From the 12th to the 14th the storms over England were local and not as a rule severe, and on the 15th conditions were fine and anticyclonic. On the 16th the continental depression spread definitely northwestward, and on the 17th and 18th there was a shallow belt of relatively low pressure over the British Isles, dividing the anticyclone into two portions—a typical thundery situation. The renewal of the thundery weather was heralded on the 16th by a falling barometer and by large quantities of high and medium clouds, including alto-cumulus castellatus, moving from the southeast, over a northeast wind at lower levels. Some showers fell on that day from a high level, and during the following night and early morning thunderstorms occurred near the east coast from Kent to Spurn Head. These storms were associated with the replacement of cool North Sea air by warm air coming over from the continent, forming a "warm front." By next day the warm air covered a considerable area, and the solar heating raised the temperature to near 80° F. Severe thunderstorms broke out in the afternoon, notably over London, Westminster having 60 mm. of rain. Next day

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(June 18th) the storms developed over a larger area, extending to southern Scotland and Wales. Cheltenham recorded 90 mm. and Greenwich 67 mm. There were several deaths from lightning. The Ascot racecourse was flooded and racing was abandoned for the first time on record. The only considerable part of England which escaped was the southwest and the neighbourhood of the south coast. (The upper wind drift was from a southerly point on both days, but was too slight to bring across the French thunderstorms, so that the strip within 30 or 40 miles of the south coast escaped.*) The worst storms on the 18th occurred at the fringe of a cooler southwesterly current, under-cutting the warmer air, which afterwards spread over the country and brought the thundery weather to an end.

Upper air observations at Duxford showed the typical thundery conditions, namely, an adequate moisture supply and a lapse-rate of temperature slightly above the saturated adiabatic through a great range of height. The upper air temperatures were practically identical on the 17th and 18th, and were well above the normal for June, the excess being 10° F. at 5,000 feet and 8°F. at 16,000 feet. Upper wind observations showed that there was a mass movement of the air at all levels from the southeast, bringing over continental air, presumably already in the thundery state. Thunderstorms had been widespread and severe on the continent for some time past. In such prolonged thundery spells there must be some means of maintaining the moisture supply, for though some of the rain is re-evaporated, much of it must run off. The necessary supply is doubtless maintained by the convergence of the surface winds into the low-pressure area, due to friction with the ground. Since the water content of the atmosphere almost always decreases upwards, convergence at the bottom is a very effective means of maintaining or increasing the total water content over a given area. Observations of both the surface and the upper winds provide no evidence that there was any inflow of Atlantic air during the period June 12th to 18th. The converging air was all continental, except for a little from the North Sea.

The intensity of the storm of June 18th in the Royston district was to some extent demonstrated by the unpleasant experience which I had whilst returning by road from Essex on that afternoon.

We ran into heavy rain just before reaching Royston, and after passing through Royston the downpour became torrential. About a mile from Royston and at about 2.45 p.m. B.S.T. my engine stopped—I believe this was due to the suction of the fan drawing water through the radiator on to my plug leads, as

*See "A Problem of Convection," *Meteorological Magazine*, 64, 1929, p. 213.

after the elapse of about 10 minutes the engine fired and I was able to proceed again.

Meanwhile four cars came to a standstill behind mine. Also during this period the electrical display was decidedly impressive, and I witnessed for the first time of my life a "ball discharge." The ball appeared to be the residual of a flash and descended at about an angle of 45° to the horizon, finally coming to rest at what appeared to be the height of the top of a telegraph pole some 300 or 400 yards distant along the railway line (L.N.E.R.). The ball illuminated the district much in the manner one would expect from a large magnesium flare, and remained brilliant for apparently several seconds. It then decreased in brilliance, and after a brief period during which it exhibited a red glow it died out completely. Several other lightning discharges took place shortly afterwards and, judged by their intensity, they were unpleasantly close.

At about 2.55 p.m. I was able to proceed, but in another mile or so my engine stopped again and I was again forced to wait—probably until the heat of the engine had dried the plug leads.

N. H. SMITH.

An Investigation of the Statistical Probability of Rain in London

By D. DEWAR, B.Sc.

IN order to investigate the statistical probability of rain of various amounts in London, the hourly tabulations of rainfall from Kew Observatory for the 50 years 1872 to 1921 were analysed as follows. The month was divided into three periods, 1st-10th, 11th-20th, 21st-end of month, and each day into four quarters or intervals of 6 hrs (1 a.m.-7 a.m., 7 a.m.-1 p.m., 1 p.m.-7 p.m., 7 p.m.-1 a.m.), which are referred to as the "early morning," "forenoon," "afternoon," and "night" intervals, respectively. Allowance was made for the fact that the last period of the month does not usually consist of 10 days. The total amount of rain which fell during each of these intervals of the day was noted, and the interval classified as "A" if 0·04 inch or more was recorded, "B" if 0·02 or 0·03 inch, and "C" if 0·01 inch. On occasions when snow had fallen and had not been autographically recorded, the total amount was distributed evenly over the hours during which it was presumed it had fallen. On several occasions, dew or melting frost had deposited an amount "C" in the check gauge; these were disregarded so as not to bias the 7 a.m.-1 p.m. interval in favour of that particular amount.

The results were then summarised by finding the number of occasions during the 50 years on which rain of a given amount fell in a given interval; the probability of rain of that amount

in that interval was then found by dividing the number of occasions when it occurred by the number of occasions when it could have occurred. This investigation, which is being carried out at the suggestion of Colonel Gold, will require some time to complete, but it was thought that the results obtained for January were of sufficient interest to warrant their being published. The probabilities of rain of each amount, during each interval of the day, for each of the three periods of the month were found in this way, and are given in Table I :—

TABLE I.—PROBABILITY OF RAINFALL OF DIFFERENT AMOUNTS.

Time	Forenoon (7 a.m.—1 p.m.)			Afternoon (1 p.m.—7 p.m.)			Early Morning (1a.m.—7 a.m.)			Night (7 p.m.—1 a.m.)			mean
Amount	A	B	C	A	B	C	A	B	C	A		C	A
Jan. 1-10	·126	·052	·064	·136	·050	·036	·134	·046	·060	·130	·064	·038	·132
„ 11-20	·108	·056	·048	·096	·060	·038	·086	·048	·048	·110	·046	·030	·100
„ 21-31	·078	·049	·047	·118	·062	·036	·105	·044	·036	·078	·064	·038	·095
Mean	·104	·052	·053	·117	·057	·037	·108	·046	·048	·106	·058	·035	

Amount—A = ·04 inch or more
B = ·02 or ·03 inch
C = ·01 inch

These figures reveal several interesting facts.

The probability of rain of amount "A" in each of the four 6-hour intervals during the first 10 days of January is considerably in excess of that for the next two 10-day periods. The excess is so marked that there is a reasonable presumption of reality: out of 2,000 6-hour intervals in each of the 10-day periods in the 50 years considered, there were 263 wet (A) intervals in the first 10 days of January, compared with 200 such intervals in the second 10 days and 188 in the last 10 days (adjusted from the number in the last 11 days, viz., 206).

From columns 2 and 11 of Table I it will be seen that there is a remarkable parallelism between the probability of rain of amount "A" in the forenoon interval (7 a.m.—1 p.m.) and the night interval (7 p.m.—1 a.m.), and from columns 5 and 8 between the afternoon interval (1 p.m.—7 p.m.) and the early morning interval (1 a.m.—7 p.m.), that is, at 12-hour intervals.

Rain of measurable amount in a 6-hour interval falls on about one day out of five: rainfall of 1 mm. or more (amount "A") occurs on about one day out of nine. If the figures for the morning and afternoon are put together they show that even in January the odds are more than four to one against an appreciable amount of rain (1 mm. or more) falling during the working day (7 a.m.-7 p.m.) in London.

On the whole, the chance of slight rain (amount "C") is greater in the early morning and forenoon than in the afternoon or evening.

Cold Fogs over the Sea

On the morning of May 1st, 1930, it was noticed that the temperature during a fog at Inchkeith, in the Firth of Forth, was surprisingly low, considering that the wind was blowing in from the open sea. The temperature was 49°F. at 1h. and 38°F. at 7h. G.M.T., and was considerably lower than that of any air which had entered the North Sea during the previous few days. The mean sea temperature off east Scotland is 43°F. in April and 48°F. in May. Similar cold sea fogs have been observed before, a conspicuous case occurring at Yarmouth on March 12th and 14th, 1929. On the first of these dates the temperature was 32°F. at 7h., and on the second 33°F., with a light wind off the sea on each occasion. On the 14th the maximum at Yarmouth and other east coast stations was only 36°F. The inversion was very large, the temperature at Duxford being 49°F. at 2,190 feet, and 52°F. at 3,650 feet. The temperature of the North Sea was unusually low in March, 1929, but even if it was 6°F. below normal and only 36°F. off Yarmouth, it was higher than the morning temperatures noted above.

The most likely explanation seems to be that radiation from the upper surface of the fog may sometimes influence the temperature even at the bottom of the fog. Even if we started with an inversion within the fog itself, caused by cooling over a sea or land surface, radiation from the upper surface of the fog (assuming no further cooling at the bottom) would produce convective equilibrium or instability within the fog, and an inversion above it. Soundings at Kew Observatory have shown that fogs which have lasted for some time have inversions above them rather than within them. At the daily conference in the Forecast Room of the Meteorological Office on May 1st, Col. Gold suggested making an estimate of the outward radiation from the fog, on the assumption that the net loss was a quarter of the radiation from a black body, the remaining outward radiation being balanced by the downward radiation from the sky. At a temperature of 278°A. (41°F.) the full radiation is ·49 gm. cal. per sq. cm. per minute, a quarter of this being ·12. The remaining ·37 is about equal to the mean sky radiation observed in April in southeast England. Suppose the fog to be 150 metres thick, then allowing for the latent heat of condensation a loss of ·12 cal. per sq. cm. per min. could cool the entire mass 1·0°C. per hour. This figure seems on the high side, and the assumption that even a thick fog radiates like a black body may not be correct. If the fog radiated and absorbed like a grey body, so that some of the sky radiation passed right through it, all the figures given would have to be reduced in the same proportion. This reduction might be large in the case of thin

fog, but should be small for a dense fog. Scattering also requires consideration, but one would not expect this to be large for long-wave radiation. Thus the order of magnitude of the figures given is probably correct.

After convective equilibrium had been established in the fog as the result of the radiation from its upper surface, the temperature at its lower surface would fall below that of the sea, and a transfer of heat from the sea to the air would commence. If this took the form of radiation only, and the sea and the fog radiated as black bodies, while the downward sky radiation remained constant at ·37, a balance between the gain of heat at the bottom of the fog and the loss at the top would not be reached till the fog was 9°C. (16°F.) colder than the sea, assuming a sea temperature of 280°A. (45°F.). This figure is excessive, and it is evident that turbulence is the main factor in diffusing up the heat from the sea surface. The best expression for the eddy flux of heat is that given by D. Brunt,* namely,

$$K\rho c_p \left(\frac{dT}{dz} + a\right),$$

where K is the coefficient of eddy diffusivity, ρ the air density, and c_p the specific heat of air at constant pressure. The expression in the bracket is the difference between the observed lapse-rate of temperature and the adiabatic rate, the flux being upwards when the adiabatic rate is exceeded In the case of foggy air we may take the saturated adiabatic rate, if we neglect the fall of the fog particles through the air. Unfortunately there are too many unknown factors for a complete solution of the problem. The observed fact is that the air temperature at the height of a few metres is sometimes a few degrees colder than the sea, though never much colder. If a balance is reached with a difference of 2°C., the upward radiation flux is only about ·02 cal. per sq. cm. per min., and if the loss at the top of the fog is ·12, we require an eddy flux of ·10 to make up the balance. If we take $K = 10^4$ sq. cm. per sec., a a value of $\left(\frac{dT}{dz}+a\right)$ equal to 6°C. per 100 metrés gives the required amount of flux. This involves a lapse-rate much above the adiabatic, which could not exist through a large thickness of the atmosphere, but which might exist within a few metres of the surface. Such lapse-rates are normal within a few metres of a land surface in the middle of the day,† and the fact that the air temperature on ships is often some degress colder than the sea temperature seems to show that they also exist over the sea.

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*The Transfer of Heat by Radiation and Turbulence in the Lower Atmosphere. *London, Proc. R. Soc., A.*, 124. 1929, pp 201–18.

†See "A Study of the Verticle Gradient of Temperature in the Atmosphere near the Ground." By N. K. Johnson, *London. Meteor. Office, Geoph. Mem., No.* 46 (M.O. 307 f.).

A persistence of such conditions involves the curious anomaly that K is smaller in the region of excessive lapse-rate than it is a little higher up, with a lapse-rate about equal to the adiabatic. This must be due to the small size of the eddies near the surface of the land or sea. The flux of heat mentioned above can of course also be obtained with a smaller lapse-rate and a higher K. A flux of that order of magnitude seems to be indicated by the rate of warming of cold air currents over warmer seas in normal conditions, when the heat is diffused up to a kilometer or more.

Turbulence in a fog layer would not necessarily be visible to an observer under it, but it should affect the upper surface. I have on several occasions seen fog layers resembling typical strato-cumulus clouds when viewed from above. The turbulence would of course normally thicken the upper part of the fog at the expense of the lower part.

Sometimes land fog in winter drifts over the English Channel and persists, as on February 11th to 16th, 1927, when shipping was seriously delayed. Some time ago I examined some temperature records from Portland Bill Lighthouse, where the fog prevailed for most of the period, comparing the screen readings with those of a thermometer outside a window near the top of the lighthouse. The exposure of the latter thermometer was unsuitable for accurate comparisons, but on the occasions in question the difference was so large that it is certain that the lapse-rate exceeded the dry adiabatic. Radiation from the fog seems the only reason for its failure to dissipate in mid-Channel.

I have had the advantage of discussing the matter with Colonel Gold. C. K. M. Douglas.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, June 18th, at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lempfert, C.B.E., M.A., F.Inst.P., President, in the Chair.

C. E. P. Brooks, D.Sc., and S. T. A. Mirrlees, M.A.—Irregularities in the Annual Variation of Temperature in London.

The late Dr. A. Buchan enumerated six cold and three warm spells which recurred about the same dates in each year in Scotland in the 1860's. To find whether these or similar spells occurred also in London, averages of temperature at Kew Observatory were found for each of the periods 1871 to 1900 and 1901 to 1929, and were combined into five-day means, a "spell" being defined as a period of five days. The details of the curves of annual variation obtained in this way were

almost completely different in the two periods, and do not give the slightest support to the idea that there is any abiding tendency for any part of the year to be either cold or warm for the season. In particular, the famous " Buchan cold periods " are abnormally warm as often as they are abnormally cold. The nearest approach to a regular cool period occurs in summer, when the annual rise of temperature ceases towards the end of July and gives place to a period of variable temperature which continues until the autumn fall sets in about the middle of August; but none of these oscillations occur with sufficient regularity to enable us to pick out any special dates as definite warm or cold periods. Throughout most individual years temperature rises and falls so rapidly that whatever dates are selected a cold spell can be found a few days before or after, and to an uncritical mind this verifies the existence of a cold spell on the selected dates. On the other hand it would be as easy to " prove " the existence of a warm spell on the same dates. Two interesting features were brought out by the curves: since 1900 winters have been on the whole abnormally warm, and there has been another period of high temperature during the last ten days of May. Neither of these tendencies existed between 1871 and 1900, and there is no reason to expect that they will continue indefinitely in the future.

The paper was followed by a good discussion, in which the method of smoothing over five days was criticised as masking cold and warm spells which covered only one or two days. The suggestion was made that Buchan's results had been generally accepted because though in many years marked cold or warm periods did not occur, yet when they did, they tended to fall on or near Buchan's dates. On the other hand, Mr. Mirrlees thought that the belief had persisted because meteorologists had been more interested in explaining the existence of cold and warm periods than in finding out whether they did, in fact, exist.

C. E. P. Brooks, D.Sc.—The Climate of the First Half of the Eighteenth Century.

Is our climate changing? The answer seems to be that there has been no appreciable change since 1750, but there is much evidence that the first half of the eighteenth century was abnormally dry in western Europe. Rainfall figures are discussed for 29 places, and the average deficiency of rainfall is calculated as 7 per cent. in England, 15 per cent. in France and 9 per cent. in Russia and Sweden. South-westerly winds were less frequent than now and north-easterly winds more frequent; the area of low pressure near Iceland was therefore probably less intense than at present. The deficiency of rain was greatest in the south of France, while Italy and Tunis were wetter than now, suggesting that the stormy area in the Gulf

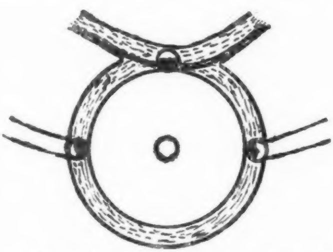
of Lions was highly developed. The inquiry is extended to other parts of the world; the slow growth of the "big trees" shows that rainfall was slight in western United States of America, and the Lake of Mexico was at a low level, but the Caspian Sea and the Nile floods were high, and there were many floods in China. All these facts agree that the general atmospheric circulation, which governs the rainfall of western Europe and California, was weak; the southerly monsoons of Abyssinia and China, which override the general circulation, were abnormally strong and brought heavy rainfall to those countries.

Correspondence

To the Editor, *The Meteorological Magazine.*

Halo Phenomena

On May 1st a prismatic solar halo of 22° became visible about 14h. continuing to sunset. A bright prismatic mock sun developed on the halo to the left of the true sun about 17h., and a white mock sun to the right shortly afterwards. The mock sun ring was visible outside the halo, curving slightly upwards, but was not continued through the true sun. At 18h. an upper contact arc with a third mock sun developed, the complete phenomenon being shown in the attached figure. A pink sun pillar about 10° in height was seen at 19h. 15m.



Although the formation is not a very uncommon one, in the present case it was exceptionally complete, and the prismatic colouring of unusual intensity, the red and green of the upper contact arc being vivid, and was continued after the sun had set. No coloration was observed in the extended arcs of the mock sun ring which remained white throughout. The same evening at 22h. a lunar halo of 22° with a single mock moon was observed. On May 5th, about twenty minutes before sunrise, 4h. 26m., the top arc of a very bright prismatic solar halo was visible. There were some indications of thin cirri over the sky, but the sun's disc, pink in colour, was sharp at sunrise without any indication of blurring. This halo remained visible to 14h. All times are G.M.T.

Worcester Park, Surrey. SPENCER C. RUSSELL.

At 9h. (G.M.T.) on May 1st, I observed at Bagshot, Surrey, part of the halo of 22° and one "mock-sun." It was faint and of a whitish colour.

At 17h. 55m. on the same day I saw the halo of 22° at Bagshot,

complete except for one small portion which was broken off by the horizon. The two parhelia and the halo were quite brilliant, and showed prismatic colouring. The sky was covered with thin cirro-stratus.

G. D. WATERER.

Wellesley House, Wellington College, Berks. May 6th, 1930.

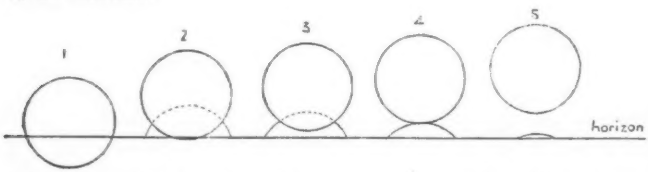
On Sunday evening, June 15th, between 8.30 and 8.45 p.m. (S.T.) parhelia were observed, no halo was visible, but the prismatic colours at the points of illumination were seen. At 9 p.m. the parhelia faded, but a sun pillar appeared for a few minutes.

ROBERT GRAY.

Oaklands, Dorstone, Herefordshire. June 14th, 1930.

Inferior mirage at Sunrise?

While waiting for the ferry to India, at Talaimannar, last Friday, March 28th, I saw the sun rise over the sea to the east, about 6.15 a.m. As its lower edge rose above the horizon, it seemed, as a member of our party expressed it, as if the sun were dragging another sun out of the sea. After a few seconds, this mock sun, when a part only of its diameter had risen to sight, separated from the real sun, and appeared to sink again to the horizon.



I should imagine that this was a case of inferior mirage, the phenomenon actually taking place as shown in the diagram. Stages 2 and 3 would be obscured by the glare from the sun, which was appreciable, and this and the unexpectedness of the phenomenon would explain the illusion of the dragging upwards of the image.

H. JAMESON.

Colombo University. April 2nd, 1930.

Trees damaged by Lightning

Whilst reading the *Meteorological Magazine* of July, 1929, I was interested in the photo of the elm tree struck by lightning at Chorley Wood.

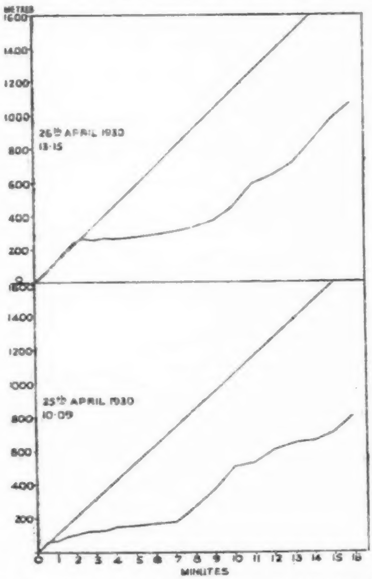
On July 24th, 1929, I was on holiday in France and stayed one night at Chalons-sur-Marne. Between 7 p.m. and 9 p.m. there was a violent thunderstorm accompanied with heavy rain and wind. Next morning on leaving for Paris, I passed, in a distance of thirty kilometres, twelve or more trees which had been struck by lightning in the manner shown in the photo which forms part of the frontispiece of this number of the magazine. The bark from these trees was strewn across the road, and many of the trees were split into halves.

A. H. WHITE.

London Road, North End, Portsmouth. August 24th, 1929.

Downward Air Currents

I am enclosing a couple of graphs showing the vertical movement of pilot balloons as measured here by the tail method on April 25th and 26th. Horizontal movements were in all cases concerned between southwest and west, and velocities were fairly uniform and did not exceed 5 metres per second on the 25th or 6 metres per second on the 26th. As the vertical angles concerned were mostly between 10° and 20° the low heights cannot be explained away as due to the tails not being vertical, while the possibility of a leak in the balloon is negatived by the almost normal rate of ascent between the 7th and 10th minutes on the 25th and from the 13th minute onwards on the 26th. The graphs are pretty definite in showing that for two consecutive flights the downward movement of the air in the neighbourhood of 300 metres altitude was sufficient to cancel the balloons' own buoyancy over a period of several minutes.



ALTITUDES OF PILOT BALLOONS AS OBSERVED AT COLOMBO TOGETHER WITH THE THEORETICAL ASCENT AS DEDUCED FROM FREE LIFT AND WEIGHT.

This fact is interesting in itself, but possesses added interest in connexion with what followed it. I have pointed out pre

viously that a monsoonal advance has a tendency to drive the air in front of the lower half of it downwards as well as forwards, owing to the wave front of such an advance not being vertical, but more advanced at the level of maximum velocity than at the surface (*Q.J.R. Meteor. Soc.* 55, p. 373) and have frequently noticed that such downward movement, as indicated by the pilot balloons, has been followed by increased monsoonal activity, not immediately, but within a couple of days. April 27th is rather early in the year for pure monsoonal effects, but not too early for the composite effects connected with its earliest stages, and in this case the meteorological history of the few days following these low vertical velocities has been most significant.

From the 24th to the morning of the 28th the rainfall at Colombo was only 0·05in. On the night of the 27th-28th the wind was light or moderate, but remained in the southwest quadrant all right for the first time this year. This is one of the recognised milestones in the early development of the monsoon and occurred eleven days earlier than it did last year.

What probably interested the public was the aftermath of this premature attempt of the monsoon to take charge, on the night of the 28th, a wind velocity of 66 miles per hour was recorded with 4·21 inches of rain. This was certainly not a pure monsoon effect, but equally certainly in the category referred to above as a composite effect connected with it. A pure intermonsoon convectional thunderstorm might have given the rain, but hardly the wind velocity, which was from the east.

A. J. Bamford.

Colombo Observatory, Colombo. May 6th, 1930.

NOTES AND QUERIES

The Effect of Exposure on Climate

In the *Meteorological Magazine* for May, 1929, attention was drawn to Dr. Geiger's account of meteorological investigations carried out on the Hohenkarpfen in the Swabian Jura. In a further paper* the effect of wind velocity upon the skin of air covering the hillsides is discussed. The temperature gradient in the early afternoon between 25 and 100 cm. above the ground (based upon observations on the summit and at eight places about half-way up the hill) is shown to decrease with increase of wind in cloudy or overcast weather. In clear weather, however, the gradient is less with so-called " moderate " than " light " winds while with " strong " winds it is greater. The words " moderate " and " strong " are applied to winds of average velocity 3·4 and 5·9 m./s. respectively, which is rather mislead-

* Messung des Expositionsklimas. *Forstwiss. Centralbl. Berlin*, 51, 1929 pp. 305-15.

ing—apparently only light and moderate winds are included. It is argued that in fine weather the whole skin of air becomes more uniformly warm but with increasing winds (5·9 m./s.) the top part of the skin is more disturbed than the bottom so that the temperature gradient increases somewhat within the first metre. Taking all cases together and the temperature gradient with winds of average velocity 2·2 m./s. as a standard, the gradient is shown to decrease only 9 per cent. with winds of 3·4 m./s. and 19 per cent. with those of 5·9 m./s.

In this, the last paper but one of the series the author turns from the discussion of averages to isolated cases and describes two thunderstorms which occurred on May 16th, 1926. The first and minor storm was experienced in misty weather with a cold NE. wind at surface below a warm SE. current which had come over the top of the Swabian Jura. The second storm was caused by the down-rush of still colder air which, owing to the masses accumulated by northerly winds in the Rhine valley between the Swiss Jura, the Vosges and the Black Forest, had been forced over some of the lower ridges of the Black Forest and approached the Hohenkarpfen as a SW. wind. The distribution of wind and rainfall on the various slopes of the hill is discussed, the strongest winds occurring on the northwest and southeast slopes (*i.e.*, on the flanks relative to the wind direction) in accordance with the normal distribution mentioned in an earlier paper. A further example of the wind distribution is contained in an account of the storm of June 12th, 1926, which appears in the ninth and last paper of the series.* On the western sides of the hill the force of the wind at its maximum was two to three times as great as on the eastern sides.

The last paper also includes a discussion of the distribution of rainfall in five thunderstorms during the period of investigation and an interesting account of the diurnal and other variations of wind velocity on different parts of the hillsides. The relation between the force of the wind in normally quiet weather and that in rough conditions is shown in a diagram to indicate the liability to damage by storm.

The work concludes with a brief recapitulation of the results of the investigations, the pages on which each point is discussed being clearly stated.

Observations in the Sahara

An interesting set of observations has been communicated to the Meteorological Office by Dr. T. F. Chipp, Assistant Director of the Royal Botanic Gardens, Kew. Dr. Chipp, who had been attending a conference in Algiers, took part in an expedition to the western Hoggar (or Ahaggar) district of the Sahara.

* *Ibid.* 51, 1929, pp. 637-56.

about 1,000 miles south of Algiers, and obtained a number of meteorological observations at various points on the route between Fort Miribel and Tamanrasset and in the western Hoggar near Abelessa and Silet. A whirling hygrometer was used thrice daily on several days, maximum and minimum thermometers were set up when possible, and frequent observations of wind and sky conditions were made.

Dr. Chipp's results are probably fairly representative of conditions during March, 1930, in an area centred about lat. 23° N. long. 4½° E., at a height of about 3,000 feet above sea level.

Mean time of observation	6½h.	13h.	18h.
Mean temperature (°F)	57	84	76
Mean relative humidity (per cent)	33	14	16

Mean maximum 90°F. Mean minimum 51°F.

In this table, the humidities given were computed with Pernter's "strong wind" formula, which is probably appropriate for readings of a whirling hygrometer in these conditions.

Winds were rather variable, mainly north-easterly in the first half of the month. Cloudiness, while small, tended to increase during the day, the average figures, based on numerical values assigned to such descriptions as "cloudy," "few clouds," "overcast," being, for the morning observation, less than one-tenth, afternoon two-tenths, evening four-tenths. Heavy thunderstorms with much rain were experienced from 6h. to 8h. on March 2nd, while the expedition was on the Plateau de Tademait.

Meteorological records from the Sahara are uncommon, but it so happens that there are other observations with which those of Dr. Chipp may be compared. In March, 1923, the Olufsen expedition was travelling northwestward from Tamanrasset, and the results for that period are as follows:—

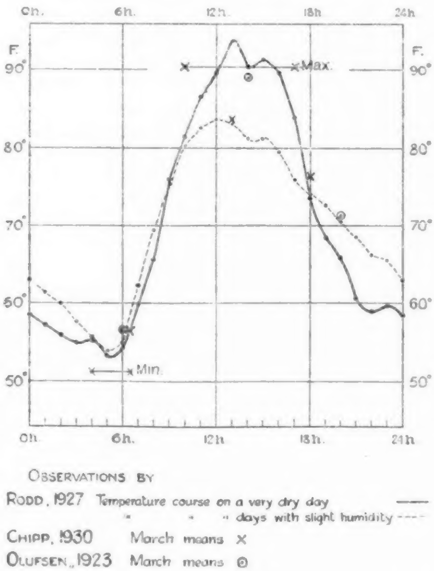
Hour of observation	6h.	14h.	20h.
Mean temperature (°F)	57	89	71

These figures may be taken as applying to an area centred about lat. 25° N., long. 2° E. Values of relative humidity are not given, as it is not known what formula was used in the reduction of the observations. We have no direct observations of the complete diurnal course of temperature in this part of the Sahara, but the general type may be assumed to be similar to that found in neighbouring parts. In Fig. 1 an attempt has been made to compare the two sets of observations by the use of thermograms obtained by Mr. F. R. Rodd* in the Aïr region, about 500 miles southeast of Tamanrasset.

The dotted curve represents temperature variation on a November day, and may be taken as typical of a day when the amount of moisture in the air is exceedingly small. The plain

*See *London, Meteor. Office Geophysical Memoirs, No.* 48.

curve is intended to show conditions when the amount of moisture in the air is more appreciable; it is the mean curve for several days in September, displaced about 20° down from its true position to bring it into range with the other observations. It shows the same sharp rise in temperature during the morning, but a more rounded afternoon maximum than that of the very dry November day. It will be seen that apart from one discrepancy the observations of the more northern expeditions agree quite well with the type of diurnal variation observed in the southern Sahara, while the two sets of morning observations are in remarkably good agreement. The discrepancy is between Dr. Chipp's figures for 13h. and maximum temperatures. One must accept the observations of the whirling hygrometer as reliable, and the probable explanation is that the exposure of the maximum thermometer was in some way defective. Possibly the readings of the minimum thermometer also are slightly affected; Olufsen's 14h. readings certainly agree well with Dr. Chipp's maximum, but it is not known how the thermometers of the former were exposed. The question of the reduction of psychrometer readings made in conditions of such extraordinarily low humidity is a vexed one; Olufsen's view is that when one gets to the region of 12 per cent. one should enter "less than 12 per cent.," rather than any lower figure.



Remarkable Hailstorm in Iraq

The report of the Meteorological Section in Iraq for April, 1930, contains an account of a remarkable hailstorm which visited Hinaidi and Bagdad on April 24th. On the morning of that day the weather conditions were unsettled, the morning chart showing a primary depression extending eastwards along the

eastern Mediterranean into Syria and a secondary depression south of Rutbah. The primary depression moved slowly north-eastwards, but the secondary travelled rapidly eastwards across western Persia. At Hinaidi the morning began with light north-east to east winds, which became calm at 3h. G.M.T. (6 a.m. local mean time). At 3h. 35m. a line-squall occurred, the wind reaching a velocity of 36 m.p.h. and veering from south-east to west. A second line-squall followed at 4h. 34m., in which the wind rose to 30 m.p.h. and veered from north-west to north-east. Subsequently the wind gradually became more easterly and maintained an average velocity of 32 m.p.h. At 14h. 15m. G.M.T. slight rain commenced, and at 14h. 30m. the wind began to drop to calm and a heavy fall of hail occurred, continuing for seven minutes. The most remarkable features of the hail-storm were the large size and slow terminal velocity of the hailstones and the absence of dust in their composition. Some idea of their size is given by the illustration forming part of the frontispiece of this number of the magazine.

An average specimen was cut open and was found to consist of five layers of alternating hard transparent ice and soft white ice, arranged as follows:—

Core of hard transparent ice	$\frac{1}{8}$ inch diameter.
Layer of soft white ice	$\frac{1}{4}$ inch thick.
Layer of hard transparent ice	$\frac{1}{8}$ inch.
Layer of soft white ice	$\frac{1}{4}$ inch.
Outer crust of hard transparent ice ...	$\frac{1}{8}$ inch.

The total diameter was one and five-eighths inch, and in calm air the terminal velocity of hailstones of this size would be nearly 30 miles per hour. The descent of several specimens was actually timed against the wall of a building, and it was found that they fell 40 feet in about three seconds, giving a velocity of only 9 miles per hour. The observer is to be congratulated on his enterprise in obtaining this measurement, which appears to indicate an upward current of air of at least 30 m.p.h. at a comparatively low elevation.

Hailstones which fall in Iraq usually contain about 25 per cent. of dust, but those of April 24th appeared perfectly clean, even when examined through a lens.

A Peculiar Deposit at Southport

During the night of March 8th—9th a singular yellowish brown substance was deposited from the atmosphere in the neighbourhood of Southport. Subsequently, Mr. J. Baxendell forwarded for examination a number of objects bearing traces of the deposit, and stated that "early on the 9th objects looked as though coated with ochre, but rain spoiled it." Dr. J. S. Owens reported that when examined under the microscope the

deposit was found to consist of brownish semi-transparent particles, irregular in shape, with adhering smoke particles. He concluded that the substance was not silicious and was probably of local origin as the particles were rather large to travel any distance. They did not, however, appear to be ash or dust from chimneys.

In a later letter Mr. Baxendell furnished the following information:

"After writing to Mr. Bilham with the samples of the deposit, my deputy observer chanced to meet me, and on my mentioning the deposit to him, he at once explained that he had examined some under the microscope, immediately after it fell, and that he found it to consist of algae (class *Isokontae*, species: *Trentepohlia;* I understood him to say). My deputy observer (Mr. A. R. Yarwood), is a very keen and well-equipped microbiologist, and his conclusions are generally fully reliable. He added that these algae could not be recognised when dry. They are common epiphytes on leaves in tropical countries, but in England are only found on the windward sides of rocks, in mountain districts, where they prefer, particularly, carboniferous limestone and silurian Rocks. He has definitely found them in the Peak district of Derbyshire, and it is noteworthy that the direction of the wind at the time of the shower was from that very point. On their way here, they evidently encountered soot, particles of which adhered, as you found, to several of them. It is, of course, well known that such algae are propagated by means of spores, which are dispersed by the wind, and which, on gathering moisture, assume the vegetative state, as filaments—this particular kind being of an orange colour, or rather, perhaps, yellowish-brown. The Southport deposit was remarkably thick, and extended densely over at least 10 square miles, and thinly over many more. It happens that Mr. Yarwood witnessed a similar but redder fall in Norfolk in 1917, which proved to be another member of the same family."

It may be remarked that the general wind direction during the night in question was from S. to SW., and it seems more likely therefore that the algae were derived from the mountains of Wales than from those of Derbyshire. In any case the occurrence furnishes an interesting addition to the already long list of air-borne vegetable, animal and mineral substances, numerous references to which are to be found in meteorological literature.

Reviews

India Meteorological Department. *Scientific Notes.* Vol. I. Nos. 4-6, pp. 37-67. Prices 10d., 8d., 9d.

The first paper "On temperatures of exposed rails at Agra," by K. R. Ramanathan, M.A., D.Sc., contains results of great importance to the engineer who has to allow for the expansion

of the ironwork of bridges, &c. As a comparison is made with the temperatures in a Stevenson screen and with a grass minimum thermometer it is possible to apply the results to other localities having similar conditions as regards radiation. In any case the method of carrying out the tests over nearly a year will serve as a model to anyone who has to make similar investigations in another country.

The second paper is on the "Frequency of Thunderstorms in India." In connexion with the sending of airships to India a knowledge of thunderstorm frequency is important. The records of the past 10 years were therefore examined, but in a number of cases it was found that these were unreliable, the number of storms recorded being clearly too few. The southern areas such as Ceylon and Madras get most storms, Cochin, for instance, gets 101 per year and Lower Burmah as many as 154. There are two maxima in the south, in April and October or November; as we move northward the months of maxima generally approach each other.

In the third paper Rao Saheb M. V. Unakar, B.A., deals with "Correlations between pre-monsoon conditions over northwest India and subsequent monsoon rainfall over northwest India and the Peninsula." The formula at present in use for foreshadowing the monsoon in northwest India contains as one of the factors the snow accumulation on the Himalayas in May. As, however, the numerical estimate of snow is rough and uncertain, Mr. Unakar has worked with rainfall in the Himalayas and in northwest India in March and the discharge of the Ganges in May. A considerable improvement follows and instead of a correlation of $-0{\cdot}40$ which is the relationship between the monsoon of northwest India June to September and the snowfall accumulation in May he gets a total correlation of 0·59 with the three factors, snow, rain and river. The writer then makes a further examination of the months of July and August, which are the mid-monsoon months, and for the monsoon of these two months the total coefficient with preceding snow, rain and river is as big as 0·66. The practical application of these results, however, to the improvement of the existing formula for foreshadowing the monsoon still remains to be done. This memoir contains tables of data which should be very useful to other workers.

E. W. Bliss.

Deutsches Meteorologisches Jahrbuch für 1927. *Freistaat Sachsen.* Edited by Direktor Prof. Dr. E. Alt. Jahrgang 45, Dresden, 1929.

This quarto volume of nearly 200 pages of text and more than 50 pages of charts presents the meteorological statistics of Saxony for a single year, with a notable abundance of detail. Full

daily observations at three separate hours are given at Wahnsdorf and the high-level station of Fichtelberg, daily rainfalls for about 500 stations and a general summary of the weather of each month. Subsequent sections of the year book give monthly and annual climatological summaries for 32 stations, frequencies of various phenomena, phenological observations and hourly means for each month, while the monthly distribution of all elements is shown in a series of charts. The two appendices give results of registering balloon ascents at Leipzig and Dresden and a dissertation by Dr. E. Göhlert on the rate of physiological cooling in Germany on the basis of a formula devised by Dr. Leonard Hill.

Obituary

We regret to learn of the death on May 27th, 1930, at the age of 73, of Father José Algué, S.J., Director of the Philippine Weather Bureau, Manila, from 1897 to 1924.

We regret to learn of the death, on May 11th, 1930, at the age of 50, of Dr. Wilh. R. Eckardt, Director of the Meteorological Observatory and Weather Service at Essen.

We also regret to learn of the death on April 5th, 1930, at Hamburg, at the age of 66, of Kommodore Hans Ruser, Captain of the *Gauss* on the German South Polar expedition of 1901-3.

News in Brief

Colonel Sir Henry G. Lyons has been reappointed Director and Secretary of the Science Museum, and will hold that Office until October, 1933.

Dr. O. Hoelper has succeeded the late Prof. Dr. P. Polis as Director of the Meteorological Observatory at Aachen.

Erratum

May, 1930, page 98, line 22 *for* " cutting " *read* " culling."

The Weather of June, 1930

Sunny weather prevailed generally over the whole country during the month. In the south and east it was also dry and warm, but in the north and west it was unsettled, the total rainfall being above the normal and temperature slightly below normal. Thundery conditions were experienced frequently. Slight rain occurred in many parts of England on the 1st and 2nd, with a heavy rainstorm in central London on the 2nd, but anticyclonic weather spread across the whole country on

the 3rd and temperature rose gradually until the 6th, when 80° F. and above was experienced inland, 82° F. at Cullompton and 81° F. at Sheffield. On the 7th the winds became northerly with a subsequent drop in temperature, but the weather continued sunny, the 6th, 7th, and 8th being the three sunniest days at the beginning of the month; Aberdeen had 15·8hrs. on the 7th, Gorleston 15·5hrs. on the 6th. There followed a period of cloudy weather as a depression over Iceland moved eastwards. Rainfall was generally slight except in Scotland, north England and Wales on the 9th when 2·56 in. fell at Oakeley (Merioneth) and 1·70 in. at Rosthwaite (Cumberland). On the 10th and 11th fair weather returned to Scotland, 16·1hrs. bright sunshine were recorded at Aberdeen on the 11th, but this did not extend to England until the 12th, when the high pressure area over central Europe began to move north and west. From the 12th to 19th local thunderstorms were almost of daily occurrence,* but apart from these the weather was generally fair and sunny. Temperature was high generally during this period, reaching 83° F. at Greenwich and 80° F. at Cambridge and Norwich on the 18th and 79° F. at Fort Augustus on the 16th. From the 20th to the end of the month westerly winds prevailed with fair sunny weather generally in the south, but rain at times with sunny intervals in the north and west. Temperature was slightly lower than during the previous days, but again exceeded 80° F. locally on the 30th. Thunderstorms were experienced generally between the 22nd and 24th. Ground frosts occurred on one or two nights at a few places during the month, the ground minimum temperature falling as low as 25° F. at Rhayader on the 27th. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs).
Stornoway	231	+53	Liverpool	214	+14
Aberdeen	244	+60	Ross-on-Wye	236	+39
Dublin	251	+62	Falmouth	219	— 2
Birr Castle	217	+53	Gorleston	243	+33
Valentia	225	+37	Kew	227	+30

Pressure was above normal over Scandinavia, Holland, Germany, and in a belt across the North Atlantic from south Spain to Bermuda and Newfoundland, the greatest excess being 3·3 mb. at Skagen and Bornholm, while pressure was below normal over Spitsbergen, Iceland, the British Isles, France, Switzerland, and Italy, the greatest deficit being 8·5 mb. at Reykjavik. Temperature was generally above normal except in Portugal and rainfall deficient except in Scotland, Spitsbergen, and locally in Sweden. In Gothaland and part of Norrland, however, it was only 50 per cent. of the normal.

A severe storm in the Seine and Oise department, France, did considerable damage to the village of Chevreuse on the 2nd,

* See p. 129.

and some loss of life and much damage to crops was caused by the torrential rains experienced in Castile and Andalusia during the first days of the month. A violent thunderstorm swept over Canton Berne, on the 7th, causing a landslide and damage to crops, and several villages in the Bernese Oberland were flooded on the 8th after a thunderstorm accompanied by hail. A hailstorm on the 11th devastated vineyards near Geneva. Heavy thunderstorms were also experienced in northern France and Switzerland on the 12th and 14th with resulting floods. The Saint Barthelemy torrent again overflowed in the Rhône Valley near St. Maurice on the 23rd owing to heavy rains. Cold weather with heavy rain and snow occurred in Iceland about the 27th. Abnormal heat and drought were experienced in Hungary during the month.

The intense heat recorded in Egypt resulted in the deaths of two women on the 11th.

The monsoon was active in Burma and Assam during the week ended the 11th, and had advanced along the west coast of India to Bombay by the 9th. A train from Ahmedabad was struck by a cyclonic storm near Himmatnagar on the 10th, and many of the coaches were blown off the track and overturned. One passenger was killed.

Rain fell generally throughout New South Wales on the 1st and 2nd, and again about the middle of the month, as much as 14in. being reported to have fallen in two days in the north-eastern area.

Much needed rain fell in all districts of the Prairie provinces during the week ended the 24th, but in Ontario three trains were wrecked about the 26th owing to floods caused by heavy rains. In the United States temperature was high for the time of year in the Lake region, Mountain region and along the Pacific coast, and low elsewhere during the first part of the month. Later it was high over most of the country. Rainfall was deficient in the west and in excess in the northeast. In Argentina temperature was mainly above normal and rainfall in excess at first but later deficient.

The special message from Brazil states that the rainfall in the northern regions was irregular in distribution with 0·59in. above normal and scarce in the central and southern regions with 0·43in. and 1·10in. below normal respectively. Only four anticyclones passed across the country. The crops, however, were generally in good condition despite the abnormal conditions. At Rio de Janeiro pressure was 1·4mb. below normal and temperature 3·6°F. above normal.

Rainfall, June, 1930.—General Distribution

England and Wales	59	per cent of the average 1881-1915.
Scotland	109	
Ireland	88	
British Isles	78	

Rainfall: June, 1930: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square.........	3·18	157	*Leics* .	Belvoir Castle............	·75	39
Sur .	Reigate, Alvington.....	·48	23	*Rut* .	Ridlington................	1·00	...
Kent .	Tenterden, Ashenden...	1·05	55	*Linc* .	Boston, Skirbeck........	1·09	60
,, .	Folkestone, Boro. San..	·86	...	,, .	Cranwell Aerodrome...	·91	54
,, .	Margate, Cliftonville...	1·04	59	,, .	Skegness, Marine Gdns	1·65	92
,, .	Sevenoaks, Speldhurst	·70	...	,, .	Louth, Westgate........	1·95	90
Sus .	Patching Farm.........	1·14	56	,, .	Brigg, Wrawby St.....	2·60	...
,, .	Brighton, Old Steyne..	·69	38	*Notts* .	Worksop, Hodsock.....	2·48	124
,, .	Heathfield, Barklye....	1·07	51	*Derby*.	Derby, L. M. & S. Rly.	1·76	78
Hants.	Ventnor, Roy. Nat. Hos.	·69	38	,, .	Buxton, Devon Hos....	2·59	80
,, .	Fordingbridge, Oaklnds	·47	25	*Ches* .	Runcorn, Weston Pt...	1·08	42
,, .	Ovington Rectory.......	·36	16	,, .	Nantwich, Dorfold Hall	·70	...
,, .	Sherborne St. John.....	·60	28	*Lancs*.	Manchester, Whit. Pk.	2·48	94
Berks .	Wellington College.....	·28	13	,, .	Stonyhurst College.....	3·15	103
,, .	Newbury, Greenham...	·56	26	,, .	Southport, Hesketh Pk	1·40	64
Herts .	Welwyn Garden City...	·49	...	,, .	Lancaster, Strathspey	2·14	...
Bucks.	High Wycombe.........	·46	24	*Yorks*.	Wath-upon-Dearne.....	·64	29
Oxf . .	Oxford, Mag. College..	·86	40	,, .	Bradford, Lister Pk....	2·57	109
Nor .	Pitsford, Sedgebrook...	1·16	60	,, .	Oughtershaw Hall......	2·69	...
,, .	Oundle.....................	·23	...	,, .	Wetherby, Ribston H.	2·06	98
Beds .	Woburn, Crawley Mill	·45	23	,, .	Hull, Pearson Park.....	1·46	71
Cam .	Cambridge, Bot. Gdns.	...	...	,, .	Holme-on-Spalding.....	1·47	...
Essex .	Chelmsford, County Lab	·53	28	,, .	West Witton, Ivy Ho.	1·23	...
,, .	Lexden Hill House....	·41	...	,, .	Felixkirk, Mt. St. John	2·05	94
Suff .	Hawkedon Rectory.....	·81	39	,, .	Pickering, Hungate....	1·78	...
,, .	Haughley House	·48	...	,, .	Scarborough.............	1·59	86
Norf .	Norwich, Eaton...	·89	46	,, .	Middlesbrough..........	1·16	61
,, .	Wells, Holkham Hall	...	...	,, .	Baldersdale, Hury Res.	1·86	...
,, .	Little Dunham..........	1·26	56	*Durh* .	Ushaw College..........	1·15	53
Wilts.	Devizes, Highclere......	1·99	88	*Nor* .	Newcastle, Town Moor	·60	28
,, .	Bishops Cannings.......	2·06	85	,, .	Bellingham, Highgreen	1·28	...
Dor .	Evershot, Melbury Ho.	·62	27	,, .	Lilburn Tower Gdns....	·95	...
,, .	Creech Grange..........	·56	...	*Cumb*.	Geltsdale..................	2·27	...
,, .	Shaftesbury, Abbey Ho.	1·09	47	,, .	Carlisle, Scaleby Hall	2·79	111
Devon.	Plymouth, The Hoe...	·65	30	,, .	Borrowdale, Seathwaite	5·20	80
,, .	Polapit Tamar...........	·81	38	,, .	Borrowdale, Rosthwaite	4·28	...
,, .	Ashburton, Druid Ho.	...	...	,, .	Keswick, High Hill.....	2·82	...
,, .	Cullompton.......	·50	24	*Glam* .	Cardiff, Ely P. Stn.....	·73	29
,, .	Sidmouth, Sidmount...	·28	13	,, .	Treherbert, Tynywaun	4·24	...
,, .	Filleigh, Castle Hill....	·77	...	*Carm* .	Carmarthen Friary.....	2·46	86
,, .	Barnstaple, N. Dev. Ath.	·59	26	,, .	Llanwrda	2·84	84
Corn .	Redruth, Trewirgie.....	1·81	73	*Pemb* .	Haverfordwest, School	2·35	87
,, .	Penzance, Morrab Gdn.	1·39	63	*Card* .	Aberystwyth.............	2·36	...
,, .	St. Austell, Trevarna...	·91	35	,, .	Cardigan, County Sch.	1·29	...
Soms .	Chewton Mendip........	·62	32	*Brec* .	Crickhowell, Talymaes	1·20	...
,, .	Long Ashton.............	1·98	...	*Rad* .	Birm W. W. Tyrmynydd	1·87	57
,, .	Street, Millfield	1·00	...	*Mont* .	Lake Vyrnwy............	2·89	91
Glos. .	Cirencester, Gwynfa....	2·21	92	*Denb* .	Llangynhafal.............	·77	...
Here .	Ross, Birchlea............	·65	30	*Mer* .	Dolgelly, Bryntirion...	2·99	86
,, .	Ledbury, Underdown..	1·70	75	*Carn* .	Llandudno................	1·21	60
Salop .	Church Stretton.........	·96	40	,, .	Snowdon, L. Llydaw 9	8·25	...
,, .	Shifnal, Hatton Grange	·82	37	*Ang* .	Holyhead, Salt Island	1·56	72
Worc .	Ombersley, Holt Lock	1·19	53	,, .	Lligwy......................	1·46	...
,, .	Blockley..................	2·58	..	*Isle of Man*			
War .	Farnborough.............	1·95	82		Douglas, Boro' Cem....	2·23	92
,, .	Birminghm, Edgbaston	1·35	58	*Guernsey*			
Leics .	Thornton Reservoir....	1·82	84		St. Peter P't. Grange Rd.	1·10	59

Rainfall : June, 1930 : Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Wigt.	Pt. William, Monreith	2·16	...	*Suth.*	Loch More, Achfary...	5·25	142
,,	New Luce School......	...	...	*Caith.*	Wick......	3·19	177
Kirk.	Carsphairn, Shiel......	3·92	...	*Ork.*	Pomona, Deerness......	1·93	106
,,	Dumfries, Cargen......	...	...	*Shet.*	Lerwick......	2·98	167
Dumf.	Eskdalemuir Obs.......	4·18	133	*Cork.*	Caheragh Rectory......	3·33	...
Roxb.	Branxholm......	2·15	96	,,	Dunmanway Rectory...	3·40	97
Selk.	Ettrick Manse......	3·45	...	,,	Ballinacurra......	1·91	73
Peeb.	West Linton......	2·61	...	,,	Glanmire, Lota Lo......	2·55	94
Berk.	Marchmont House......	1·64	71	*Kerry.*	Valentia Obsy......	3·65	114
Hadd.	North Berwick Res.....	1·60	96	,,	Gearahameen......	4·60	...
Midl.	Edinburgh, Roy. Obs.	1·81	98	,,	Killarney Asylum......	2·88	99
Ayr.	Kilmarnock, Agric. C.	3·04	138	,,	Darrynane Abbey......	2·81	89
,,	Girvan, Pinmore......	2·33	81	*Wat.*	Waterford, Brook Lo...	2·59	96
Renf.	Glasgow, Queen's Pk..	3·22	139	*Tip.*	Nenagh, Cas. Lough...	2·11	86
,,	Greenock, Prospect H.	3·70	102	,,	Roscrea, Timoney Park	2·81	...
Bute.	Rothesay, Ardencraig.	3·34	114	,,	Cashel, Ballinamona...	2·63	114
,,	Dougarie Lodge......	2·77	...	*Lim.*	Foynes, Coolnanes......	2·29	89
Arg.	Ardgour House......	6·97	...	,,	Castleconnel Rec.......	2·16	...
,,	Manse of Glenorchy...	4·32	...	*Clare.*	Inagh, Mount Callan...	4·05	...
,,	Oban......	3·26	...	,,	Broadford, Hurdlest'n.	2·84	...
,,	Poltalloch......	3·46	113	*Wexf.*	Newtownbarry......	...	...
,,	Inveraray Castle......	4·81	122	,,	Gorey, Courtown Ho...	1·46	60
,,	Islay, Eallabus......	4·26	163	*Kilk.*	Kilkenny Castle......	2·59	107
,,	Mull, Benmore......	8·60	...	*Wic.*	Rathnew, Clonmannon	1·91	..
,,	Tiree......	4,08	...	*Carl.*	Hacketstown Rectory..	2·10	75
Kinr.	Loch Leven Sluice......	2·39	109	*Leix.*	Blandsfort House......	3·08	119
Perth.	Loch Dhu......	4·30	163	,,	Mountmellick......	2·63	...
,,	Balquhidder, Stronvar	2·33	...	*Off'ly.*	Birr Castle......	...	...
,,	Crieff, Strathearn Hyd.	2·02	76	*Dubl.*	Dublin, FitzWm. Sq...	1·68	86
,,	Blair Castle Gardens...	2·43	123	,,	Balbriggan, Ardgillan.	1·49	74
,,	Glen Bruar, Bruar Ldg.	2·59	...	*Me'th.*	Beaupare, St. Cloud...	2·14	...
Angus.	Kettins School......	1·92	103	,,	Kells, Headfort......	2·48	93
,,	Dundee, E. Necropolis	1·89	105	*W.M.*	Moate, Coolatore......	1·58	...
,,	Pearsie House......	2·38	...	,,	Mullingar, Belvedere..	1·63	63
,,	Montrose, Sunnyside...	...	...	*Long.*	Castle Forbes Gdns......	1·65	64
Aber.	Braemar, Bank......	1·56	80	*Gal.*	Ballynahinch Castle...	4·26	120
,,	Logie Coldstone Sch....	1·82	93	,,	Galway, Grammar Sch.	2·58	...
,,	Aberdeen, King's Coll.	2·21	129	*Mayo.*	Mallaranny......	...	...
,,	Fyvie Castle......	3·04	...	,,	Westport House......	2·16	80
Moray.	Gordon Castle......	1·13	55	,,	Delphi Lodge......	6·03	...
,,	Grantown-on-Spey......	1·58	70	*Sligo.*	Markree Obsy......	2·92	97
Nairn.	Nairn, Delnies......	1·15	65	*Cav'n.*	Belturbet, Cloverhill...	2·16	88
Inv.	Kingussie, The Birches	1·51	...	*Ferm.*	Enniskillen, Portora...	2·75	...
,,	Loch Quoich, Loan....	7·89	...	*Arm.*	Armagh Obsy......	1·50	60
,,	Glenquoich......	6·17	126	*Down.*	Fofanny Reservoir......	3·64	...
,,	Inverness, Culduthel R.	1·10	...	,,	Seaforde......	1·84	67
,,	Arisaig, Faire-na-Squir	3·81	...	,,	Donaghadee, C. Stn...	2·15	92
,,	Fort William......	5·99	...	,,	Banbridge, Milltown...	2·13	...
,,	Skye, Dunvegan......	5·36	...	*Antr.*	Belfast, Cavehill Rd...	2·30	...
R & C.	Alness, Ardross Cas...	1·93	85	,,	Glenarm Castle......	3·21	...
,,	Ullapool......	3·04	...	,,	Ballymena, Harryville	2·42	83
,,	Torridon, Bendamph...	4·26	104	*Lon.*	Londonderry, Creggan	3·13	111
,,	Achnashellach......	5·54	...	*Tyr.*	Donaghmore......	2·20	...
,,	Stornoway......	2·60	112	,,	Omagh, Edenfel......	2·04	72
Suth.	Lairg......	2·07	...	*Don.*	Malin Head......	2·87	...
,,	Tongue......	2·33	114	,,	Dunfanaghy......	2·62	...
,,	Melvich......	2.50	...	,,	Killybegs, Rockmount.	3·15	83

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

Climatological Table for the British Empire, January, 1930.

STATIONS	PRESSURE		TEMPERATURE							Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
			Absolute		Mean Values				Mean							
	Mean of Day M.S.L.	Diff. from Normal	Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal	Wet Bulb			Am'nt	Diff. from Normal	Days	Hours per day	Per-centage of possible
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	0—10	in.	in.			
London, Kew Obsy.	1008·4	− 9·2	56	28	48·7	38·8	43·7	+ 4·8	41·0	90	7·5	2·71	+ 0·95	21	1·4	16
Gibraltar	1019·1	− 2·1	67	43	60·1	50·1	55·1	+ 0·3	50·4	83	6·6	5·00	− 0·06	18	..	..
Malta	1018·2	+ 0·6	63	46	58·8	51·5	55·1	− 0·2	51·0	78	6·4	4·72	+ 1·51	20	4·8	48
St. Helena	1012·3	+ 2·3	..	57	..	58·5	..	..	59·5	94	8·9	1·85	− 1·12	16	..	..
Sierra Leone	1012·7	+ 1·9	90	72	86·2	73·7	79·9	− 1·4	74·8	80	4·0	0·00	− 0·41	0	..	..
Lagos, Nigeria	1008·9	− 1·0	89	69	86·5	73·9	80·2	− 0·7	75·0	88	5·5	1·38	+ 0·31	5	..	..
Kaduna, Nigeria	1016·2	+ 4·6	94	..	87·5	..	..	..	67·1	84	1·0	0·00	0·00	0	..	..
Zomba, Nyasaland	1008·2	+ 0·8	85	61	79·0	65·0	72·0	− 0·8	..	79	8·0	9·88	− 1·22	19	..	..
Salisbury, Rhodesia	1007·9	0·0	85	53	78·0	59·3	68·7	− 1·0	61·8	65	6·4	3·90	− 3·57	19	6·8	52
Cape Town	1014·6	+ 1·2	94	53	79·2	61·1	70·1	+ 0·2	61·6	68	2·0	0·76	+ 0·08	4	..	..
Johannesburg	1012·7	+ 1·4	83	47	76·0	55·4	65·7	− 0·8	57·7	73	4·8	4·89	− 1·28	18	7·7	57
Mauritius	1010·3	− 1·6	88	69	82·9	73·2	78·1	− 1·2	74·3	75	7·2	9·06	+ 1·30	26	7·5	57
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	2·32	− 1·70	..	..	..
Calcutta, Alipore Obsy.	1014·8	− 0·4	86	49	77·2	55·0	66·1	− 0·3	55·8	86	2·1	0·00	− 0·34	0*	..	..
Bombay	1012·8	− 0·8	91	60	82·9	66·0	74·5	− 0·8	63·9	71	1·8	0·00	− 0·10	0*	..	..
Madras	1013·5	− 0·6	86	63	83·3	68·4	75·9	− 0·2	71·1	87	4·6	1·47	+ 0·08	2*	..	..
Colombo, Ceylon	1011·4	− 0·1	90	69	86·5	71·6	79·1	0·0	73·8	74	4·7	5·75	+ 2·25	11	8·3	70
Hongkong	1020·4	+ 0·6	72	41	59·1	50·9	55·0	− 5·2	50·7	76	8·8	2·27	+ 0·90	9	2·3	21
Sandakan	..	..	88	70	85·1	73·2	79·1	− 0·7	75·4	81	..	18·56	+ 0·11	14	..	..
Sydney, N.S.W.	1013·6	+ 1·1	100	59	75·7	64·2	69·9	− 1·8	64·6	65	5·9	4·58	+ 0·85	13	8·0	57
Melbourne	1014·8	+ 1·9	103	47	78·2	55·3	66·7	− 0·8	57·8	55	3·3	0·14	− 1·71	4	8·4	58
Adelaide	1015·1	+ 2·1	108	50	84·5	60·0	72·3	− 1·6	59·2	35	1·5	0·02	− 0·71	1	12·5	89
Perth, W. Australia	1013·5	+ 1·0	108	54	85·9	62·9	74·4	+ 0·5	62·2	45	1·2	0·05	− 0·29	2	12·1	87
Coolgardie	1011·8	+ 0·4	115	51	96·6	61·7	79·1	+ 1·7	61·2	34	0·5	0·00	− 0·47	0	..	..
Brisbane	1011·9	+ 0·6	95	64	82·8	69·2	76·0	− 1·2	70·5	71	8·1	9·94	+ 3·67	23	4·9	36
Hobart, Tasmania	1011·1	+ 0·8	93	41	69·2	50·5	59·9	− 2·4	52·7	55	6·2	0·98	− 0·81	10	9·2	62
Wellington, N.Z.	1008·8	− 4·5	70	44	64·4	54·1	59·3	− 3·2	55·9	79	7·5	5·44	+ 2·11	19	6·3	43
Suva, Fiji	1007·2	− 0·5	92	70	86·9	75·4	81·1	+ 1·2	77·2	79	6·4	17·31	+ 6·59	25	6·9	53
Apia, Samoa	1007·2	− 0·7	88	74	86·0	76·5	81·2	+ 2·2	78·6	79	5·0	10·17	− 66·4	22	6·2	48
Kingston, Jamaica	1015·6	+ 0·5	87	64	84·3	67·3	75·8	− 1·0	65·5	84	2·6	0·90	− 0·06	5	8·2	73
Grenada, W.I.	1009·1	− 3·5	89	71	85·2	72·2	78·7	+ 1·7	73·5	77	4·7	4·98	+ 0·55	19	..	..
Toronto	1022·3	+ 4·9	47	− 4	28·9	16·7	22·8	+ 0·7	19·2	68	8·2	3·33	+ 0·46	19	2·7	29
Winnipeg	1025·0	+ 5·2	23	−35	0·0	−14·7	− 7·3	− 2·9	..	..	5·1	0·29	− 0·53	9	3·2	37
St. John, N.B.	1022·5	+ 6·8	48	− 4	28·4	11·5	19·9	+ 0·7	16·5	66	6·0	3·51	− 1·29	15	3·5	38
Victoria, B.C.	1019·4	+ 4·1	47	15	36·0	28·1	32·1	− 8·0	28·2	70	4·5	1·10	− 3·41	11	4·5	51

Victoria, B.C.	1019·4	+ 4·1	47	15	36·0	28·1	32·1	— 8·0	28·2	70	4·5	1·10	—	3·41	11	4·5	51